INVESTIGATING THE USE OF AEROGEL COLLECTORS FOR THE SCIM MARTIAN-DUST SAMPLE RETURN A. J. G. Jurewicz[1], L. Forney[2], J. Bomba[3], D. Vicker[4], S. Jones[1], A. Yen[1], B. Clark[3], T. Gamber[3], J. Goreva[5], M. Minitti[5], T. Sharp[5], J. M. Thornton[3], B. Willcockson[3], M. Zolensky[4], L. A. Leshin[5,6]; [1]JPL/CIT, 4800 Oak Grove Dr., Pasadena, CA 91109, [2]Dept. of Chemical Engineering, Georgia Tech. Atlanta, GA 30340, [3]Lockheed Martin Astronautics, P.O. Box 179, MS S-8000, Denver, CO 80201, [4]NASA JSC, Houston, TX 77058, [5]Dept. of Geological Sciences, [6]Center for Meteorite Studies, ASU, Tempe, AZ 85287, USA.

SCIM -- ***S****ample* ***C****ollection for* ***I****nvestigation of* ***M****ars* – is a Mars Scout mission concept currently under study. SCIM seeks to return samples of Martian dust and atmosphere to Earth without assuming the substantial risk and cost of landing on and launching from the Martian surface [1,2].

Background: SCIM is based upon the premise of a high-speed pass through the Martian atmosphere such that: the spacecraft approaches down to an altitude of ~40 km near the Martian equator during a high-speed pass, collects dust and atmosphere during that pass, and then travels a free-return trajectory back to Earth. Accordingly, dust collection will require particle-capture at hypervelocities equal to the speed of the spacecraft relative to the Martian dust.

Silica aerogel has already been used on MIR [3,4] to capture particles at hypervelocity in a vacuum. Similarly, the STARDUST Comet-sample return Discovery Mission [5] uses silicate aerogel as the medium for hypervelocity particle capture. However, the Martian atmosphere complicates matters significantly.

The interaction of the spacecraft with the Martian atmosphere will cause heating and a shock wave. These conditions are extreme relative to previous experiments in which aerogel was used for particle-capture. So, we look at whether an aerogel collector can be engineered to be useful.

Before capture, the interactions of the Martian dust with the atmosphere will be two-fold. First, dust particles must transit the shock-wave of the SCIM craft, and will experience heating behind the shock. Since the particles of dust will be small -- generally $\leq 10\mu m$ – breakup of the particles during the traverse of the shock itself will be a second-order effect. The primary concern is the heating that the particle will experience traveling through the atmosphere behind the shock. Simply, we want a SCIM collector to be engineered so that the particles will not melt, ablate, or metamorphose.

Second, the collector on the SCIM craft must be able to withstand the ablation and heating imposed by the traverse through the Martian atmosphere. This requires both a careful choice of aerogel and an innovative engineering design for the collector.

The search for solutions to these requirements has relied upon an integrated engineering approach. Clearly, this modeling process is iterative, and solutions vary as the geometry of the SCIM craft is optimized. However, the general approach and examples of existing model results are given below.

Particle heating: Models were developed using several steps. First, the gas flow field around the SCIM craft was modeled using Lockheed Martin Astronautic's (LMA's) ***LAURA*** Computational Fluid Dynamics (CFD) code. Once the gas flow-field was determined, particle traces were computed using JSC's particle integrator. Then, assuming reasonable material properties for the particle, transfer of heat from the atmosphere to the dust was modeled in order to determine the temperature a dust-particle achieves along each trace.

Example results from a model are given in **Fig. 1**. In this case, a 2um particle will impact the collector at approximately 590K (317C) and (2) a 10um particle will be ~250K (-23C) when it impacts the collector. If the aerogel is recessed 2cm into the collector, that extra traverse through the gas will increase the temperature of 2um and 10um particles to ~780K (510C) and ~300K (27C), respectively.

Collector heating: Here, computer models were coupled with laboratory experiments. Again, the gas flow field around the SCIM craft was modeled using LMA's ***LAURA*** CFD code. Assuming material properties, the rate of surface heating (W/cm2) could be mapped onto the face of the fin designed to hold the aerogel collector. The collector(s) could be placed at the minimum heat-flux location on the fin. Then, that heat-flux condition was simulated using arcjet tests at the Ames AHF facility and the stability of aerogel in different collector designs could be assessed.

Four arcjet tests were performed at a nominal 45W/cm2 for different collector configurations in order to assess the stability of aerogel. Each test used the same short time (5 sec). This short duration was chosen as a pass/fail screening test, and didn't necessarily define the limits of stability. The pass/fail criteria was necessary for the Concept Study, as availability of facilities and funding for arcjet testing was limited.

Two types of aerogel having different thermal capacities and durabilities (20mg/cc silica aerogel;

100mg/cc silica-carbon polymer aerogel) were tested, as were three configurations (aerogel flush-mounted in an ablator, flush-mounted in a heat sink, recess-mounted). The silicate aerogel was chosen for direct comparison with STARDUST and MIR collectors. The silica-carbon polymer aerogel was chosen because of its availability, and the fact that it was an alternate aerogel (theoretically) stable at higher temperatures. The three configurations were chosen based upon finite-element thermal modeling by L. Forney, as well as tests of techniques to minimize local heating suggested by members of the SCIM science team.

Silica aerogel was most stable when it was recessed behind an ablator (SIRCA) **Fig 2**. *In fact, there was no visible erosion of aerogel exposed to the arcjet after 5 seconds.* The only macroscopic change was the formation of whitish-yellow material (condensate from the SIRCA?) on the surface of the aerogel. Conversely, in the two experiments where silica aerogel was flush-mounted in the SIRCA, the collection surface ablated/melted-back approximately 2 to 3 mm. The erosion was slightly greater for the aerogel mounted at the stagnation point.

In sharp contrast to silica aerogel, silica-carbon polymer aerogel was relatively stable when flush-mounted. After 5s, there was some pitting, but the main collection surface appeared to survive relatively undamaged. Therefore, the result emphasizes that there are other compositions of aerogel more thermally stable than silica and that some may be useful alternative collector materials for SCIM.

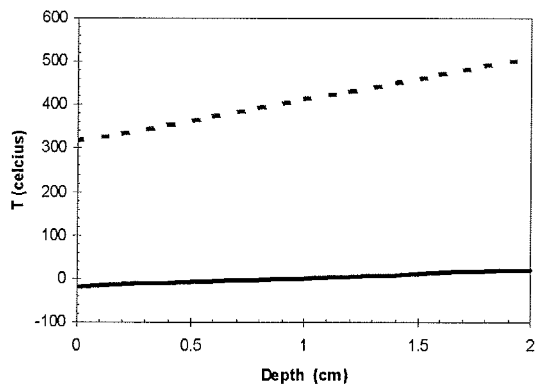

Fig. 1. Model temperature of dust impacting SCIM collector. 0 depth is surface; positive depth is recess from surface of fin to aerogel collecting surface (up to 2 cm). Calculation assumptions: a highly-modified ellipsled spacecraft geometry, an ambient atmosphere of 3.7e-4 kg/m3 and 170K (-130C), an initial particle temperature of 170K (-130C), a SCIM relative velocity of 5.8 m/s. Dashed line models 2um-diameter particles; solid line models 10um-diameter particles.

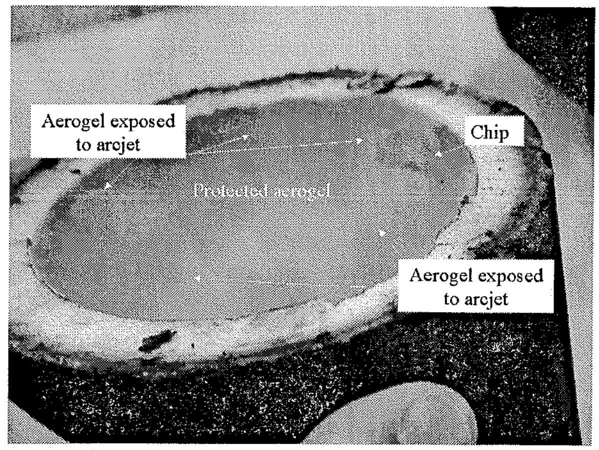

Fig. 2. Testing of recessed aerogel collector. A single piece of tested aerogel was covered with a 12mm-thick ablative silicate (SIRCA) cap perforated with 5 holes of diameters ranging between 9.5mm and 1.3mm. Arrows point to aerogel corresponding to holes in SIRCA (ie., not protected).

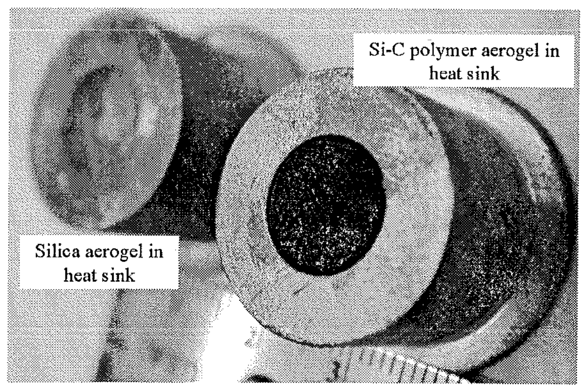

Fig. 3. Two aerogels tested at the stagnation point. In the foreground, the black (Si-C polymer) aerogel remains flush with the copper mounting, although it shows some pitting. In the background, the transleucent white (silica) aerogel has melted/ablated ~2 – 3 mm.

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